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THE SMITHSONIAN INSTITUTION'S STUDY
OF NATURAL RESOURCES

Niagara Falls: Its Power Possibilities and Preservation

(WITH TWO PLATES)

BY

SAMUEL S. WYER

Associate in Mineral Technology, U. S. National Museum



(PUBLICATION 2820)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
JANUARY 15, 1925

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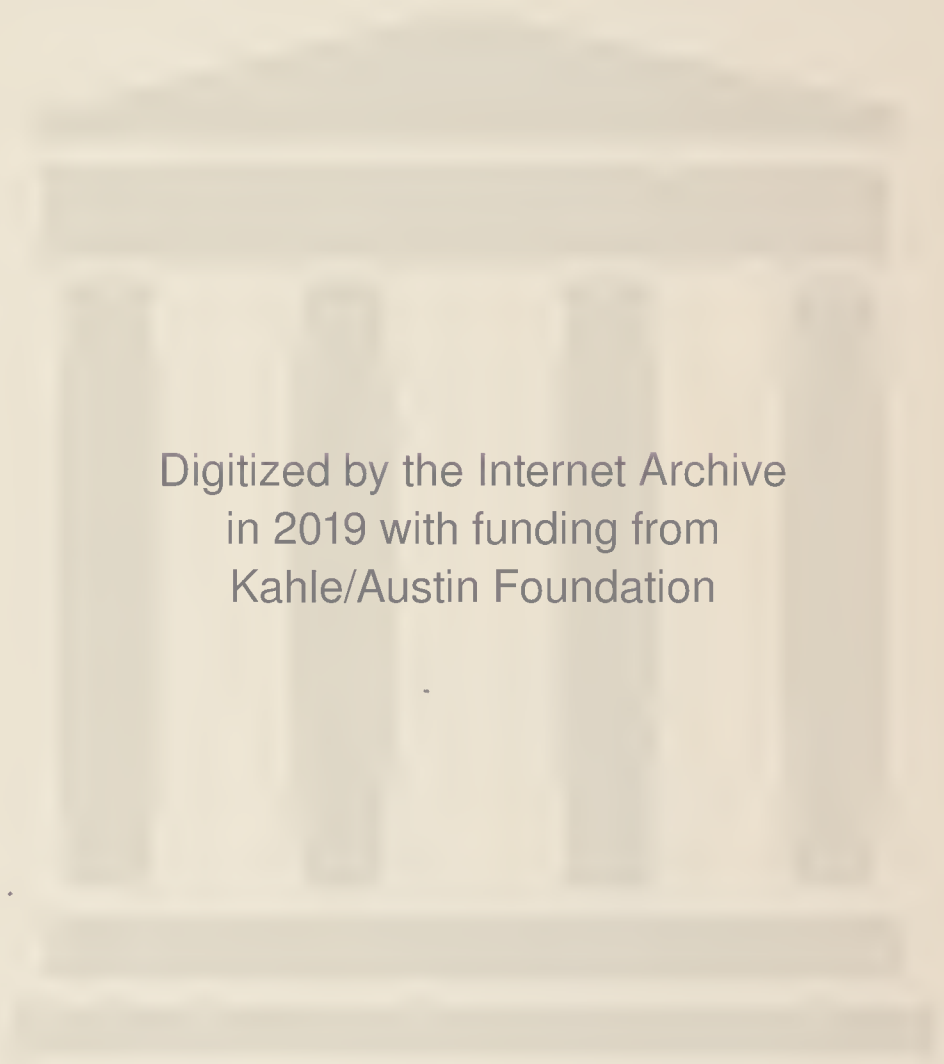


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INTRODUCTION

In the spring of 1919 the United States National Museum, under the direction of the Smithsonian Institution, issued a publication entitled "Energy Resources of the United States; a Field for Reconstruction." The statement appears therein, "Because it seems inevitable that sooner or later the energy resources of the United States must be employed more systematically and effectively than they have been in the past, this study has been made with the view towards setting forth a working plan for bettering the situation."

In 1921 the Congress of the United States authorized a survey of the power resources of the eastern part of the United States, a summary of which, popularly known as "Superpower," is given on pages 56 to 59 of The Smithsonian Institution's Study of Natural Resources Applied to Pennsylvania's Resources. "Giant Power" is merely another name for the superpower idea.

The real social significance of electric power as a means to lighten human labor and develop a more comfortable environment is just beginning to be appreciated. There is also to-day a great public interest in and much misinformation on our water power resources and methods of selling electric service to the public.

The following original investigation shows that:

1. While Niagara Falls is the most widely known, it is also the least understood of our water powers. There is only one Niagara Falls power situation in the world. Conditions here are different from every other water power.
2. Contrary to popular opinion, there is nothing magical about water power. It is worth just what can be gotten out of it in competition with electric power generated from coal, and coal represents only a small part of the total power cost to the public. Every water power development must ultimately answer the question "Will or does it pay?"
3. The Niagara River is more than a mere boundary stream between two friendly nations. It is the dividing line between two radically different methods of rendering electric service to the public; governmentally owned on the Ontario side, privately owned but governmentally regulated on the United States side. Enough data are given in Part III to permit the reader to make an evaluation of these two methods.
4. Water diversion from the Great Lakes water basin should be handled from a nationally minded viewpoint and not from the provincial aspect of any one community or interest.

5. The Canadian side of Niagara Falls—carrying 94% of the water—is rapidly, by nature's own means, destroying itself and mere non-use of the water is not preservation. Two and one-half times more power than is now developed can be developed and still maintain an adequate scenic effect. Real preservation can be brought about only by frankly facing the engineering and geologic facts now obvious and the development of an international preservation program that will insure maximum use with the continued preservation of an adequate scenic effect.

CHARLES D. WALCOTT,
Secretary, Smithsonian Institution.

January 6, 1925.

TABLE OF CONTENTS

Section	Page
Introduction	iii

PART I

FUNDAMENTAL FEATURES OF NIAGARA FALLS

1. What is water power?.....	1
2. How water power is measured.....	1
3. Source of Niagara Falls water.....	1
4. Dimensions of Niagara Falls.....	3
5. Flow data for Niagara River.....	3
6. Power of Niagara River.....	5
7. Limiting aspects of treaty.....	5
8. Electric transmission limitations.....	5
9. Unique position of Niagara Falls.....	6

PART II

ECONOMIC ASPECTS OF ELECTRIC POWER DEVELOPMENT

10. Wrong impression of word "natural".....	7
11. Source of capital.....	7
12. Meaning of the word "cost".....	8
13. Definition of profit.....	8
14. Can water power subsidize navigable waterways?.....	9
15. Fixed charges main item in power cost.....	9
16. Coal small part of steam generated electric power cost.....	9

PART III

ONTARIO AND UNITED STATES ELECTRIC SERVICE COMPARED

17. Radically different methods.....	10
18. Canada and United States plant capacities.....	11
19. Canada exports power to the United States.....	11
20. How Niagara Falls dominates Ontario's power situation.....	14
21. Niagara Falls an insignificant part of United States power situation... ..	14
22. Ontario and United States electric rate situations diametrically opposed.	14
23. Tax exemption in Ontario.....	16
24. Subsidizing rural line extensions.....	16
25. Direct contributions from Ontario Province Treasury to operating expenses	17
26. Dodging sinking fund facts.....	17
27. Two classes of securities.....	17
28. Sinking fund deficit.....	18
29. Summary of how Ontario hydro-electric system has failed to pay expenses	18
30. What Canadians must face.....	19
31. Service at cost.....	19
32. Many power consumers' rates have been increased.....	19
33. Why Ontario domestic consumers get lower priced electric service than domestic consumers in the United States.....	19

PART IV

DIVERSION OF WATER FROM NIAGARA FALLS

Section	Page
34. Two kinds of water diversion.....	21
35. Origin of Chicago's water diversion problem.....	21
36. Creation of sanitary district.....	21
37. Definition of Chicago Drainage Canal.....	21
38. Why Chicago still has a water diversion problem.....	22
39. Unnecessary use of domestic water in Chicago.....	22
40. Legal status	22
41. Water that Chicago is now diverting.....	22
42. Chicago's water diversion compared with the American Falls.....	23
43. Power loss from diverted water.....	23
44. Chicago's huge industrial sewage.....	23
45. Pollution of streams below Chicago.....	23
46. Why Chicago diverts water.....	23
47. Why Chicago must continue to divert some water.....	23
48. What Chicago should be held to.....	24
49. Welland Canal water diversion.....	24
50. New York State Barge Canal diversion.....	24
51. Proposed future canals	24

PART V

PRESERVATION OF SCENIC BEAUTY OF NIAGARA FALLS

52. Reasons for Niagara Falls sentiment.....	25
53. Grandeur aspects	25
54. Why American Falls is more beautiful than Canadian Falls.....	26
55. Eye sore effects.....	26
56. Flow needed to flush ice.....	26
57. Flow needed for scenic effect.....	27
58. Additional power that could be developed and still maintain proper scenic effect	27
59. Rate of recession.....	28
60. Why Canadian Falls is committing suicide.....	28
61. Only way to save Canadian Falls.....	28

LIST OF ILLUSTRATIONS

Figure	Page
1. Map of drainage basin and lakes collecting and equalizing flow of water to Niagara Falls.....	2
2. Map of Niagara River at Niagara Falls.....	4
3. Map of Niagara River and vicinity.....	12-13
4. Niagara Falls compared with potential undeveloped water power in Canada and United States in million horse power.....	15
Plate	Follow page
1. Aeroplane view of Niagara Falls.....	28
2. Canadian Falls	28

NIAGARA FALLS: ITS POWER POSSIBILITIES AND PRESERVATION

BY SAMUEL S. WYER,
ASSOCIATE IN MINERAL TECHNOLOGY, U. S. NATIONAL MUSEUM
(WITH TWO PLATES)

PART I

FUNDAMENTAL FEATURES OF NIAGARA¹ FALLS

SEC. 1. WHAT IS WATER POWER?

Falling water possesses energy. This may be made to do work and be converted into power. Work is overcoming resistance without regard to time; power is rate of doing work, that is, doing work within a specific limit of time. Water power is, therefore, the power that may be produced by the energy of falling water, and requires both fall and water. That is, water without a fall does not make power.

SEC. 2. HOW WATER POWER IS MEASURED

The vertical fall or head which can be made to work is measured in feet. The volume of water that can be converted into power is measured in cubic feet per second—abbreviated “second feet.” One horsepower equals one second foot falling 8.8 feet at 100% efficiency. To convert the energy of falling water into power, it is made to drive a water turbine and this in turn must drive an electric generator. Neither a turbine nor electric generator can be made 100% efficient, and usually only about 70%—but at Niagara Falls about 85%—of the energy of the falling water can be made available for electric transmission.

One horsepower is equal to .746 kw. In round numbers 4 hp. are required to produce 3 kw.

SEC. 3. SOURCE OF NIAGARA FALLS WATER

This is the Great Lakes drainage basin, as shown in figure 1. The 263,440 square miles of area in this drainage basin are made

¹“Niagara” is an old Indian name and there are thirty-nine other ways of spelling it.



up of 106,110 square miles (40%) in Canada, and 157,330 square miles (60%) in the United States.

SEC. 4. DIMENSIONS OF NIAGARA FALLS

The mean elevation of Lake Erie is 572 feet and of Lake Ontario 246 feet. The drop of (572-246) 326 feet between the Lakes is largely in 10 miles of the Niagara River, as shown below.

The Niagara River has really two falls—Canadian and American side by side, as shown in figure 2 and plate 1. The drop of the Canadian Falls is 162 feet and the drop of the American Falls is 167 feet. The American Falls has a crestline of 1,000 feet and the Canadian Falls a crestline of 3,000 feet. The American Falls passes about 6% of the total water and the Canadian Falls 94%.

The drop in 2 miles from the Chippawa-Grass Island Pool to the

Falls is	52 feet.
Mean drop at Falls.....	164 “
Drop in 8 miles below Falls—through rapids—to Lewiston.....	100 “
Drop in 10 miles of Niagara River.....	316 feet.

SEC. 5. FLOW DATA FOR NIAGARA RIVER

The following shows the typical monthly variation in mean flow out of Lake Erie into the Niagara River in 1884, a rather wet year, and 1923, an unusually dry year. The 1923 figures are below the rainfall equivalent, however, by the 8,000 cu. ft. per second that is now being diverted by Chicago, and the 4,300 cu. ft. per second now going into the Welland Canal:

	“ 1,000 ” cu. ft. per second	
	1884	1923
January	220	177
February	221	171
March	224	174
April	237	182
May	243	189
June	247	195
July	243	191
August	237	188
September	228	181
October	221	177
November	212	174
December	215	180

The natural mean flow, for 64 years, in a state of nature, is at the rate of 205,000 cu. ft. per second.

MAP OF
NIAGARA RIVER
AT
NIAGARA FALLS



FIG. 2

SEC. 6. POWER OF NIAGARA RIVER

Using the total drop between Lakes Erie and Ontario and diverting all of the water, 6,000,000 hp. could be developed. The treaty referred to in the next section limits the diversion of water to 56,000 cu. ft. per second. A part of the present Canadian development and all of the present American development is merely around the Falls and does not utilize the 100 ft. drop between the Falls and Lewiston. The above diversion is capable of now producing in round numbers 1,000,000 hp.

SEC. 7. LIMITING ASPECTS OF TREATY

The treaty between Canada and the United States—effective May 5, 1910—limits maximum aggregate daily diversion of water from Niagara River for power purposes at rate of: 36,000 cu. ft. per second to Canada and 20,000 cu. ft. per second to the United States. "The prohibitions of this article shall not apply to the diversion of water for sanitary or domestic purposes or for the service of canals for the purposes of navigation."

No records are available as to how the treaty makers arrived at these values.

As the total amount of water that may be diverted is now harnessed, there can be no further power development at the Falls under the terms of the present treaty.

SEC. 8. ELECTRIC TRANSMISSION LIMITATIONS

To transmit electric energy from the place of generation to the place of use, there are required: Step-up transformers to raise the voltage—that is, increase the pressure—, rights-of-way, steel towers and cables or wires, and step-down transformers at the end of the transmission line to lower the voltage so it can go into the terminal distributing system. Part of the energy that is received by the transmission system is lost in the transformers and lines so that the energy output of a line must always be less than the energy input.

The question as to how far it is feasible to transmit electric energy is solely one of cost, considering the investment that must be made for the equipment and the energy lost in transmission. Ordinarily about 250 miles is the economical limit.

Therefore, Niagara Falls power has a very circumscribed area of use and cannot economically be transmitted out into the middle West to compete with electric power generated in other plants.

SEC. 9. UNIQUE POSITION OF NIAGARA FALLS

Nature has made this the most unique water fall in the world because of the:

1. Combination of the huge drainage basin—for collecting the rainfall—with four large lakes acting as storage reservoirs.
2. Interconnection of lakes so as to largely equalize the naturally erratic rainfall.
3. Delivery of this entire water discharge, averaging 205,000 cu. ft. per second, at one place in the east end of Lake Erie and discharging this into the narrow Niagara River.
4. Nature-made position of the Niagara River acting merely like a notch in the brim of the water-filled basin—Lake Erie.
5. Drop of this huge volume of water averaging 6,400 tons of water per second falling 316 feet in the short distance of 10 miles, 164 feet of this drop being at the Falls and the remainder in the rapids above the Falls and the rapids below.
6. Concentration of this nature-collected source of energy contiguous to a prosperous and thickly populated Province and State; both well served with water and land transportation for the easy movement of people and goods so as to make an easy attainable local market for the power that may be developed.
7. Temperate climate conditions making for adequate rainfall and an environment for a virile and energetic population.
8. Soil and topographic conditions adjacent to the water fall that do not present serious engineering difficulties for structural work in the harnessing of the power.
9. Marked strategic advantage of the local water power plants in favor of low costs in that they have no money invested in lands for reservoirs, dams for storage of water, water control equipment, or auxiliary steam plants and are able to develop a maximum head with a minimum capital investment. This gives a marked localized advantage to the patrons which tends to further place this Niagara Falls power development in a class by itself. In brief, there is only one Niagara Falls power situation in the world.
10. Niagara River as the boundary stream between two friendly nations which immediately presents the question of joint ownership and control and the necessity of team work from the two nations in any rational program for preservation and further utilization.

PART II

ECONOMIC ASPECTS OF ELECTRIC POWER DEVELOPMENT

SEC. IO. WRONG IMPRESSION OF WORD "NATURAL"

Although the water and the cliff over which it may fall have been made by nature, they are not more natural than the soil worked by the farmer or the minerals mined by the miner. Like all other natural resources, "falling water" is impotent and of little value until someone:

1. Gets it under control and converts it into usable energy.
2. Holds it ready to meet the fluctuating market demands.
3. Transmit it to the market.
4. Prepares and delivers it to the public under usable conditions.

The four steps just mentioned require the hiring of labor and money in order to make the water power available for service to the public.

Much has been said about harnessing our water falls. However, there has been little appreciation that someone must furnish money for getting, maintaining and ultimately replacing the harness and hire labor for the continuous direction of the harnessed energy.

"To no inconsiderable degree, the attitude toward water power development is due to lack of correct information. . . . Many people do not realize, that when the hydro-electric plant is erected, less than half of the cost of the combined generating, transmission, and distributing system has been incurred. Still fewer people realize that from 70 to 90 per cent of the cost of delivering the current to the resident consumer is incurred after the power has left the generating station."¹

SEC. II. SOURCE OF CAPITAL

There is no Utopian Altruism in either capital or labor. Both are used for making returns to the owner.

There is no mysterious reservoir of capital and the money used for the carrying on of an enterprise must ultimately come directly from some individual owner and this owner rightfully has the obvious right to receive a hire or rental for the use of this, his personal property.

¹ O. C. Merrill, Executive Secretary, Federal Power Commission.

Even governmental ownership does not escape economic laws. The government in carrying on a business enterprise must borrow money just the same as a private individual. Therefore, money that has been earned and saved by private individuals must be borrowed on a rental or interest basis and mobilized. That is, the government must hire money just the same as it hires labor. In the last analysis, governmental ownership is merely governmental—and, therefore, usually political—management of private property.

Every manager of an electric power enterprise—whether governmentally owned or privately owned—has the threefold responsibility: First, to get; second, to safely ultimately return: and, third, to pay an agreed rental on the capital that is hired in accordance with the conception of the word “cost” as defined in the next section.

SEC. 12. MEANING OF THE WORD “COST”

Regardless of the academic conception of the word “cost” and the wide variation in its use, as applied to any enterprise, the word “cost” in the inexorable law of human experience must always include the following:

- a. Ordinary routine operating expenses necessary for carrying on the project, including insurance and taxes.
- b. Money out of income received from customers must be set aside each year to maintain the property in the highest state of service efficiency, and provide funds to replace equipment as it becomes unusable either through ordinary wear or becomes obsolete due to improvements in the art.
- c. Rental or hire of the money used in the enterprise, ordinarily called “interest.”

SEC. 13. DEFINITION OF PROFIT

After the three groups of expenditures in the preceding section have been fully met, then what is left represents profit, but there is no profit until these three groups have been fully met. That is, the rental of capital is an expense which must be paid before there can be a profit and, like wages, is an element of cost and not a part of profit.

Without a fair profit there is no incentive for improvement. Without improvement there can be no progress or development. Therefore, an inducing profit is fundamentally necessary to continuously and permanently stimulate development of more efficient utilization methods of our power resources and extension of public utility service.

SEC. 14. CAN WATER POWER SUBSIDIZE NAVIGABLE WATERWAYS?

Regardless of popular beliefs, water power is competitive with coal and must stand on its own feet. Water power is worth just what can be gotten out of it in competition with power generated from coal and no more. A water power development that is made to carry the cost of the works that are used for navigation service may make the cost of power so high as to make it cheaper to generate power by coal than to use the water. This competitive aspect is controlling in all cases, especially considering the smaller amount of money that is usually involved in a steam plant and the fact that a steam plant is also more flexible than a water power plant.

SEC. 15. FIXED CHARGES MAIN ITEM IN POWER COST

The major part of the total charges for electric service delivered to the ultimate consumer is constant. The cost of money—that is, items “b” and “c,” in accordance with the definition given in Section 12—employed in the production, transmission and distribution of electric energy, is the largest item in the total cost to the ultimate consumer. This is true whether governmentally owned or privately owned.

SEC. 16. COAL SMALL PART OF STEAM GENERATED ELECTRIC POWER COST

At the present time, for the entire United States, about 21 cents of the public's dollar paid for electric service goes for coal, and, of this, 7 cents goes to the railroad for transporting the coal and 14 cents for the mining operations. Therefore, when statements are made that super or giant coal burning power plants would be able to halve the cost of coal, the public jumps to the unwarranted conclusion that this would halve the cost of power. The facts of the case are that cutting the coal cost in two, would lower the power cost to the ultimate consumer only about 10% and not the 50% that the public has been led to believe.

Figure 4 shows that about 21% only of the undeveloped potential water powers in the United States are east of the Rocky Mountains. The water powers are not where the markets for power are. Coal will remain the main source of electric power for many years.

PART III

ONTARIO AND UNITED STATES ELECTRIC SERVICE COMPARED

SEC. 17. RADICALLY DIFFERENT METHODS

The Niagara River is more than a mere boundary stream between two friendly nations. It is the dividing line between two radically different methods of rendering electric service to the public. In Ontario, the plants are owned by the government. In the United States, the plants are owned privately but regulated by the government. These fundamentally distinct methods have a definite and far reaching effect on the economic structures of the two nations, thus:

1. In Ontario, the governmentally owned system sells electric service to domestic consumers at rates considerably below those prevailing in the United States, because:
 - a. Governmentally owned property is exempt from taxation. This means a gain of about 10 per cent to electric consumers with corresponding loss to tax payers, as compared with conditions in the United States.
 - b. The domestic electric rates are below cost and the loss is made up in part by higher rates for industrial power consumers than prevail in the United States, which places Canadian industry at a disadvantage.
 - c. Part of the cost comes directly out of the Province treasury in the form of contributions and subsidies.
 - d. As shown in sections 26 and 30, part of the cost has been delayed by not making provision for adequate sinking fund to retire the bonds as they mature, thus placing a burden on a future group of consumers or on the public generally to be met out of general taxation of the entire Province.
2. In the United States, the privately owned—but governmentally regulated—systems sell electric service to domestic consumers at rates higher than those prevailing in Ontario, because:
 - a. Since the property is taxed the tax comes from the consumer and this alone makes a difference of about 10 per cent over and above the average cost that would prevail if the properties were tax free as in Ontario. In the United States the electric power utilities paid approximately \$135,000,000 in local, state, and federal taxes in 1923.
 - b. Under the scheme of governmental regulation in the United States, the rates correspond substantially to the cost of the service. The domestic consumer's cost per kw. hour is more than the industrial consumer's. This, of course, means that the domestic rate per kw. hour is higher than the industrial, but it also results in giving the United States industrial consumers lower rates than the industrial consumers in Canada, thus giving United States manufacturers an advantage over Canadian manufacturers.

- c. Under the scheme of governmental regulation in the United States the capital invested is not retired, and frequently bonds are refunded. However, the income received from the public in any normal plant provides for at all times maintaining the integrity of the property value. There are no contributions from the public treasury either at present or any obligations that must be met out of the public treasury in the future. That is, the United States governmentally regulated method is based on the principle of "pay as you go" without any deferred debt for the future.

The Province of Ontario owns the generating and transmission equipment. The local distributing plants are owned by the municipalities and buy their electric current from the Province. Financial operations of the local plants are frequently confused with the Province system.

SEC. 18. CANADA AND UNITED STATES PLANT CAPACITIES

The total capacities in horsepower of the several plants on the Canadian and United States sides of the Niagara River are as follows:

Canada—

Hydro-Electric Power Commission	
Queenston Plant	350,000 hp.
Ontario Power Company Plant.....	185,000 "
Toronto Power Company Plant.....	125,000 "
Canadian Niagara Power Company Plant.....	121,000 "
International Railway Company Plant.....	2,000 "
	783,000 hp.

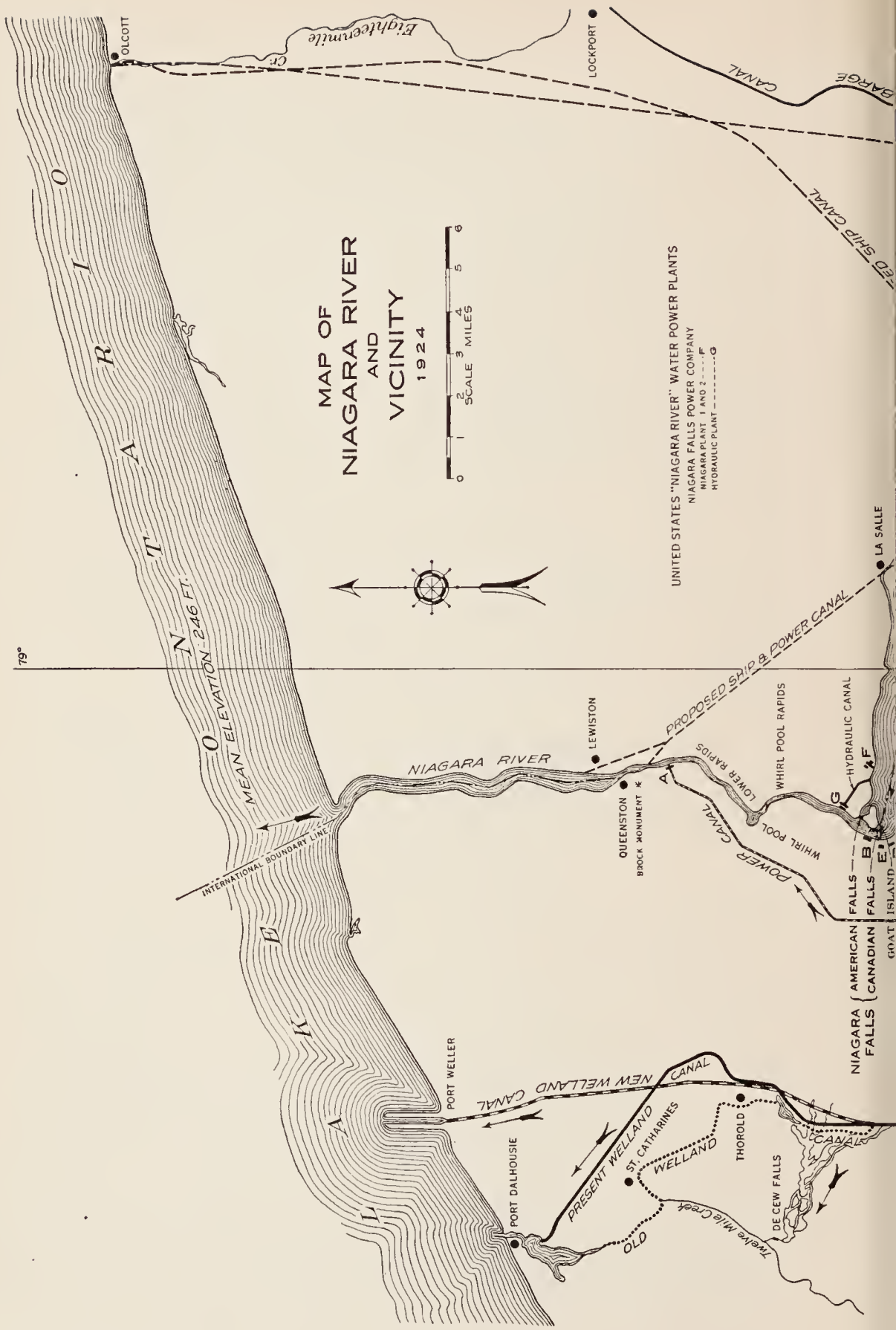
United States—

Niagara Falls Power Company	
Niagara Plant	105,000 hp.
Hydraulic Plant	455,900 "
	560,900 hp.

The continuous serving capacity of the above is about 1,000,000 hp. since part of the equipment must be held in reserve. The future capacity of the Queenston Plant will be 600,000 hp. The locations of the various plants are shown in figure 3.

SEC. 19. CANADA EXPORTS POWER TO THE UNITED STATES

About 92,000 kw. of capacity obtained by the use of 9,600 cu. ft. of water per second is exported to the United States.



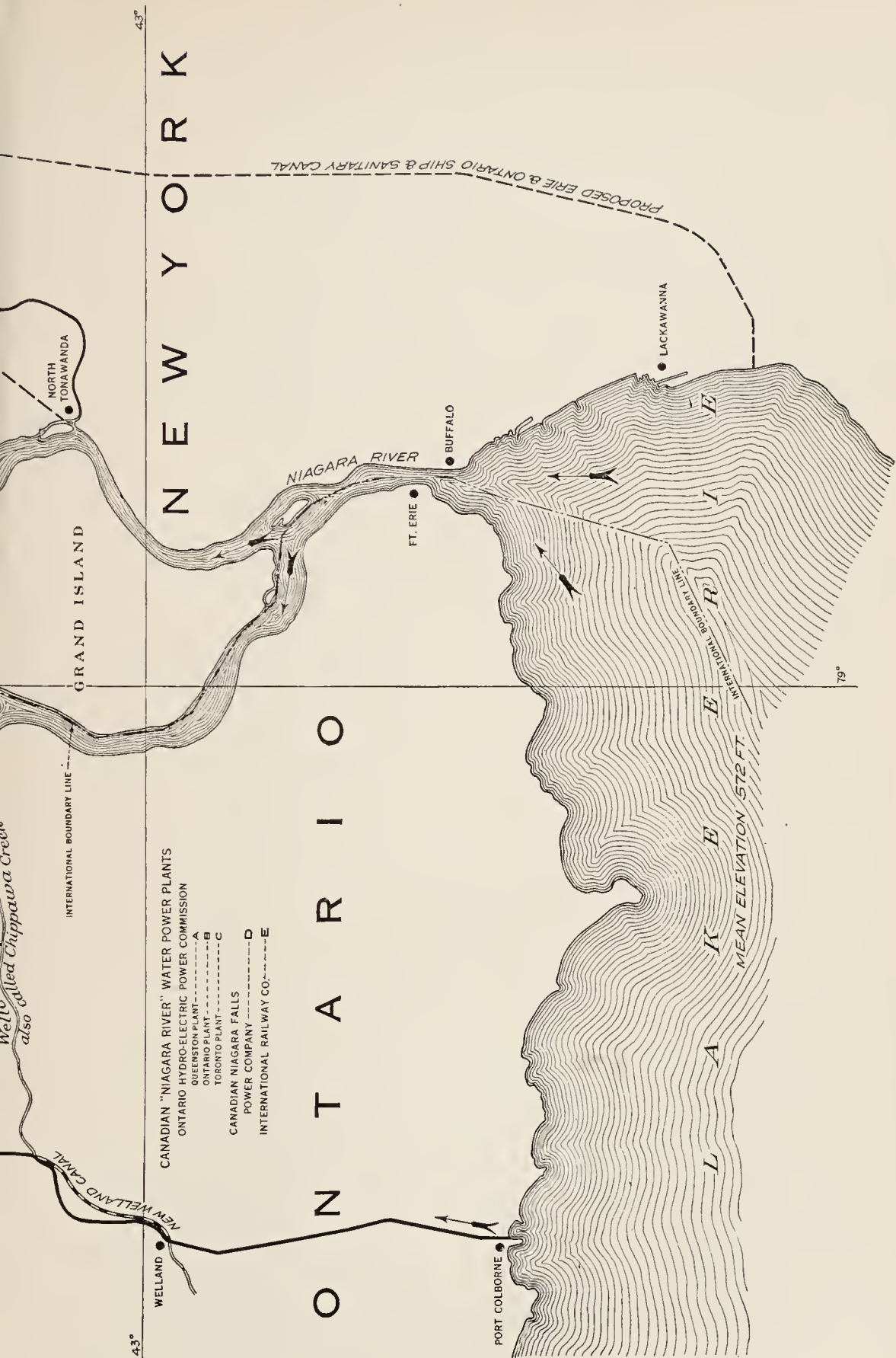


FIG. 3

SEC. 20. HOW NIAGARA FALLS DOMINATES ONTARIO'S
POWER SITUATION

The power generated at Niagara Falls dominates the whole electric power situation in Ontario, as shown by the following comparison:

Total annual billion kw. hours generated in Canada.....	6.7
Total annual billion kw. hours generated in Ontario.....	3.1
Total annual billion kw. hours used in Ontario, generated at Niagara Falls.	2.5

In considering the domination of Ontario's power conditions by Niagara Falls, it is important to bear in mind the features that make Niagara Falls the most unique water fall in the world with special reference to strategic advantage in favor of low costs as analyzed in Section 9.

SEC. 21. NIAGARA FALLS AN INSIGNIFICANT PART OF UNITED STATES
POWER SITUATION

The absence of domination of Niagara Falls, as far as electric power for public utility service in the United States is concerned, is shown in the following:

Total annual billion kw. hours generated in United States.....	55.6
Total annual billion kw. hours generated in New York.....	8.7
Total annual billion kw. hours generated in Niagara Falls and used in the United States	2.5

The smallness of Niagara Falls in comparison with the undeveloped water powers in the United States is shown in figure 4.

SEC. 22. ONTARIO AND UNITED STATES ELECTRIC RATE SITUATIONS
DIAMETRICALLY OPPOSED

The major part of the cost of generating electric current is fixed and accrues regardless of the current output of the plant. This arises from the large amount of capital that is necessary to rent or hire just to get ready to start, and the then inevitable large capital hire or rental resulting from continuing to stand ready to serve for each of the 8,760 hours of the year. Therefore, the greater the number of average kw. hours that current is used, the smaller will be the fixed charge that will be prorated on each kw. hour. That is, increase in hours use decreases the cost per hour.

The domestic consumer uses current but a short time each day, while the average industrial consumer is a long hour user. Therefore, the cost per kw. hour of industrial current is less than for the domestic current.

The dominating fundamental principle of rate charging in the United States—approved by our State Regulating Commissions—is

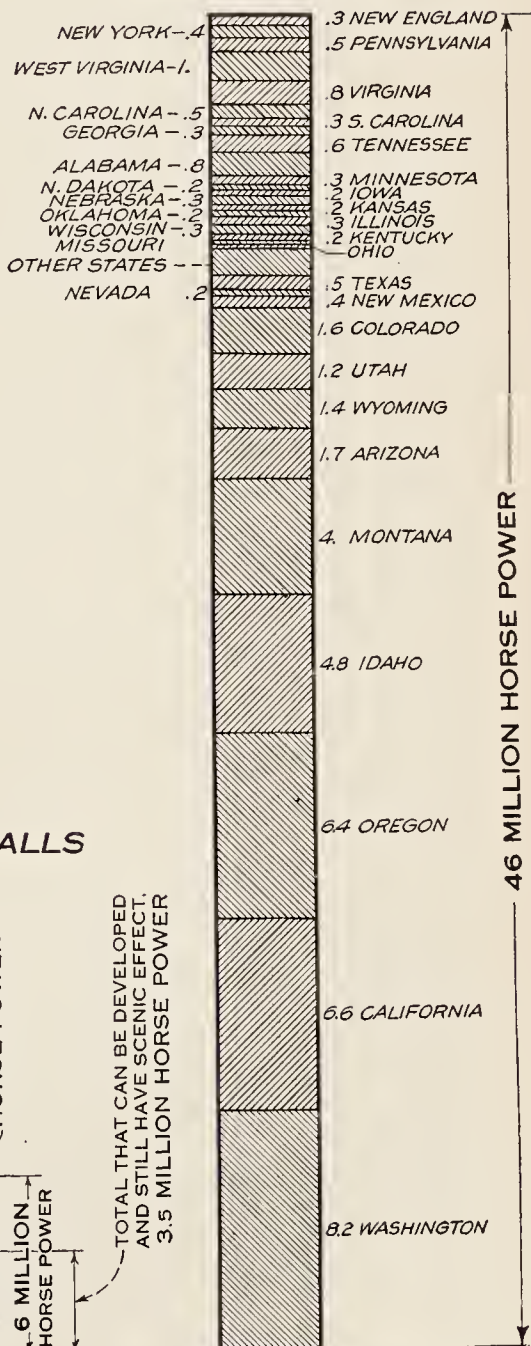
NIAGARA FALLS COMPARED WITH POTENTIAL UNDEVELOPED WATER POWER IN CANADA AND UNITED STATES IN MILLION HORSE POWER

DATA FOR CANADA:
 FROM DOMINION WATER POWER BRANCH,
 DEPARTMENT OF THE INTERIOR

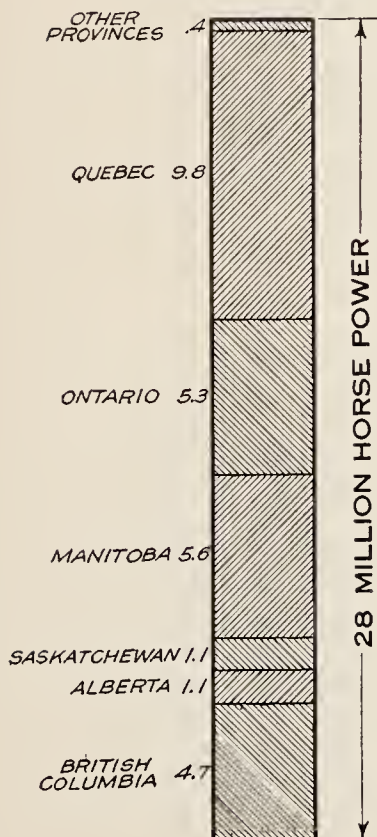
DATA FOR THE UNITED STATES:
 FROM U. S. GEOLOGICAL SURVEY

GEOGRAPHICAL DISTRIBUTION OF POTENTIAL UNDEVELOPED WATER POWER IN

UNITED STATES



GEOGRAPHICAL DISTRIBUTION OF POTENTIAL UNDEVELOPED WATER POWER IN CANADA



NIAGARA FALLS

TOTAL THAT CAN BE DEVELOPED
 UNDER PRESENT TREATY.
 1 MILLION HORSE POWER

TOTAL THAT CAN
 BE DEVELOPED
 BY HARNESSING
 ALL THE WATER.
 6 MILLION
 HORSE POWER

TOTAL THAT CAN BE DEVELOPED
 AND STILL HAVE SCENIC EFFECT.
 3.5 MILLION HORSE POWER

FIG. 4

to make each group of consumers self sustaining and pay for the cost of the service they are receiving. That is, not to carry one group at the expense of some other group. This means that the short hour domestic consumer must pay a higher rate than the longer hour and greater quantity using industrial consumer.

The Ontario method is diametrically opposite. Here the short hour domestic consumer is arbitrarily, and without regard to the cost situation, given a lower rate than the cost situation would warrant. The loss is then made up by other consumers. The Ontario domestic consumers, therefore, are carried at the expense of other consumers.

SEC. 23. TAX EXEMPTION IN ONTARIO

The governmentally owned hydro-electric system supplying 79% of the service in Ontario is not taxed. This exemption from taxation, of course, results in lowering the cost of power to the consumer. However, the gain to the consumer in the lower rates is equaled by the loss to the tax payers of the taxing districts in which the property is located.

The private property of the Canadian Niagara Falls Company at Niagara Falls pays local taxes in Stamford Township equivalent to 76 cents per horsepower of capacity. If this same rate were paid by the 660,000 horsepower governmentally owned equipment located almost entirely in Stamford Township, it would produce local taxes of \$501,600.

The total annual taxes levied by Stamford Township are \$252,000.

The privately owned plants at Niagara Falls on the Canadian and United States sides in 1923, with an income of \$7,121,928, paid taxes aggregating \$1,392,000.

For the entire United States, about 10% of the dollar the public pays for electric service goes for taxes.

SEC. 24. SUBSIDIZING RURAL LINE EXTENSIONS

In Ontario the Rural Hydro-Electric Distribution Act of 1923 provides that "50% of the capital cost of constructing and erecting transmission lines and cables in rural power districts" may be paid out of the Province treasury. This, of course, is merely subsidizing rural electric service at the expense of the public and adding to the tax burden of the farmers. In 1923 and 1924, the amount of money that was contributed from the Ontario treasury for this special class of service amounted to \$1,194,422.¹

¹ Furnished by Auditor of Province of Ontario.

In the United States, the rural consumers are not subsidized but are required to pay the cost of the service they receive.

SEC. 25. DIRECT CONTRIBUTIONS FROM ONTARIO PROVINCE TREASURY TO OPERATING EXPENSES

The Hydro-Electric Commission in the past has spent a large amount of money in giving engineering assistance, preparing estimates, making general surveys and rendering electrical inspection service to various municipalities. This has all been paid directly out of the Province treasury and in no way charged against the governmentally owned operations. The amount that has been thus contributed by the Province from 1911 to date is \$2,245,900.¹

SEC. 26. DODGING SINKING FUND FACTS

When the Ontario governmentally owned Hydro-Electric System was initiated the hope was held out to the public that the income from electric consumers would pay off the bonds. This has not been accomplished.

Contributions to the sinking fund necessary to ultimately retire the bonds, which should have been started at the beginning of operation, has been deferred from 5 to 15 years; thus placing on a future group of consumers the burden of return of money used by present consumers.

If the money to retire bonds is not provided for in the rates charged for electric service, it must ultimately come out of the Province treasury as payment of the bonds has been guaranteed by the Province of Ontario.

In the United States the plants must stand on their own feet and there can be no demand on a public treasury.

SEC. 27. TWO CLASSES OF SECURITIES

The operations of the governmentally owned hydro-electric system in Ontario—up to the town distributing plants, which are owned by the local municipalities—have been financed by two classes of securities:

- a. Bonds handled by the Hydro-Electric Power Commission.
- b. Bonds issued directly by the Province of Ontario and the proceeds of the bond sales turned over to the Hydro-Electric Power Commission.

Both classes, however, are guaranteed by the Province of Ontario and the Province is ultimately liable for the interest and sinking fund to retire the bonds.

¹ Furnished by Auditor of Province of Ontario.

SEC. 28. SINKING FUND DEFICIT

On October 31, 1924, the outstanding bonds of the Hydro-Electric Power Commission amounted to \$41,768,523. ¹ These bonds range in life from 10 to 40 years. If the electric consumers—as originally contemplated in the slogan-made public opinion of “service at cost”—had been charged an annual sinking fund allowance each year, which would ultimately retire the bonds out of electric earnings when they mature—on the basis of a 4% sinking fund compounded annually—there should have been on hand at the end of 1924 in the sinking fund to retire these bonds	\$9,579,107
The accumulated sinking fund actually paid, out of rates charged electric consumers, to October 31, 1924, was ¹	1,829,461
The shortage in sinking fund is, therefore.....	<u>\$7,749,646</u>
On October 31, 1924, the total advances to the Hydro-Electric Power Commission out of the Province treasury, separate and distinct from the Hydro bonds mentioned above, amounted to \$138,454,638. ¹ This money is supposed to be returned at the end of 30 years. If the electric consumers—as originally contemplated in the slogan-made public opinion of “service at cost”—had been charged an annual sinking fund allowance each year, which would ultimately pay back this money, out of electric earnings at the end of 30 years—on the basis of a 4% sinking fund compounded annually—there should have been on hand at the end of 1924 in the sinking fund to retire these borrowings from the Province treasury.....	11,859,541
The accumulated sinking fund actually paid out of rates charged electric consumers to October 31, 1924, was ¹	3,902,495
The shortage in sinking fund is, therefore.....	<u>\$7,957,046</u>

That is, future consumers must raise \$7,749,646 plus \$7,957,046 or \$15,706,692 in order to pay for the low priced service that the consumers in the past have received or this amount must come out of the Province treasury and, therefore, be borne by the tax payers.

SEC. 29. SUMMARY OF HOW ONTARIO HYDRO-ELECTRIC SYSTEM HAS FAILED TO PAY EXPENSES

The money that has been taken out of the Province treasury instead of out of earnings is:

1. Subsidizing rural lines, from Section 24.....	\$1,194,422
2. General expenses, from Section 25.....	2,245,900
The accrued deficits in sinking fund that have not been met out of earnings are:	
3. Hydro-Electric Commission bonds, from Section 28.....	7,749,646
4. From money borrowings out of the Province treasury, shown in Section 28	7,957,046
	<u>\$19,147,014</u>

¹ Furnished by Auditor of Hydro-Electric Power Commission of Ontario.

That is, up to date the electric consumers from the governmentally owned hydro-electric system have failed to pay the actual cost of the services they received—using the term “cost” as defined in Section 12—by \$19,147,014. The Hydro-Electric Power Commission Act was passed in 1906 and most of the development has been within the last 12-year period.

SEC. 30. WHAT CANADIANS MUST FACE

The wiping out of the indebtedness incurred—indicated in the preceding section—and the deficits that have accrued, can be accomplished only by:

1. Paying these losses out of the Province treasury and, therefore, making the tax payers in Ontario contribute and pay for the below cost service that has been rendered to electric consumers, or,
2. Marked increase in electric rates so as to get enough income from the electric consumers to not only wipe out the deficits that have accrued but also make the operation self-sustaining for the future.

SEC. 31. SERVICE AT COST

The gigantic public ownership enterprise of the Hydro-Electric Power Commission involving many millions was brought into being by a slogan-made public opinion stressing power at cost. In discussing power at cost the following questions were obviously not understood by the Ontario public:

Merely having service at cost is not enough. The important thing is who pays the cost? The particular consumer who uses the service? Is service sold below cost to one group and the losses made up on another class of consumers? Does part of the cost come out of the general public treasury? For “at cost” may mean “at cost of the public.”

SEC. 32. MANY POWER CONSUMERS' RATES HAVE BEEN INCREASED

Out of 8,390 power consumers of the Hydro-Electric Power Commission, 5,580 had their rates, in 1923, increased over what they paid in the preceding years.

SEC. 33. WHY ONTARIO DOMESTIC CONSUMERS GET LOWER PRICED ELECTRIC SERVICE THAN DOMESTIC CONSUMERS IN THE UNITED STATES

Domestic consumers in Ontario are served at lower rates than domestic consumers in the United States for the following reasons:

1. The facing of the true cost situation, and making each group of consumers pay for what they get, which is the practice in the privately owned—but State regulated—plants in the United States, is completely ignored in Ontario.
2. In Ontario the domestic consumers are given lower rates than the true cost situation warrants because the votes of the domestic consumers are needed to carry the bond issues that must be approved from time to time in order to make the needed extensions to the governmentally owned plant. This must, of course, result in the Ontario domestic consumers, as a class, being carried at a loss.
3. Serving the Ontario domestic consumers below cost may be good “vote getting” but it is unsound economics. While this naturally results in a lower domestic rate, it has worked out in Ontario that the industrial rate is higher than it would be if the domestic consumers were kept on a true cost basis, and, of course, this tends to retard industrial development.
4. Exempting the governmentally owned property from taxation makes it possible to make lower rates to the consumers by an amount equal to the amount saved in taxes. But the amount saved in taxes by the consumers is lost by the public generally and must be made up some other way. As many of the domestic consumers are not direct tax payers, this fictitious saving is reflected in higher rents and living costs, and, as a whole, results in discrimination because it means that property owners generally must pay higher taxes in order to make up the advantage gained by consumers of electric service from a governmentally owned plant. In the United States, about 10 cents of the public's dollar paid for electric service goes to taxes.
5. Expenditures of the Hydro-Electric Power Commission of Ontario, amounting to \$3,440,322, have been paid out of the Province treasury and not from income derived from power consumers. This contribution from the public treasury, of course, makes low rates possible but the public foots the bill.
6. The income derived to date from the present consumers has not been large enough by over \$15,000,000 to retire the Provincial bonds that have been issued, with the result that unless rates are raised provision to retire these bonds must come out of the Provincial treasury and, therefore, represents a burden to the population as a whole rather than to the domestic consumers that have had the benefit of this fictitious low-cost electric service.

PART IV

DIVERSION OF WATER FROM NIAGARA FALLS¹

SEC 34. TWO KINDS OF WATER DIVERSION

Water diversions from the Great Lakes may be classified as follows:

1. Those that take water out and then return it again further down stream. For instance: Operation of locks and power plants, and towns along the shore that take water for domestic purposes and then return their sewage again to the Lakes. Such diversions do no damage and require no limitation.
2. Those that permanently remove water from the Great Lakes basin. The lowered water levels thus injure navigation and make less water available for Niagara Falls. These diversions are:
 - a. Chicago Drainage Canal.
 - b. Welland Canal.
 - c. New York State Barge Canal.

SEC. 35. ORIGIN OF CHICAGO'S WATER DIVERSION PROBLEM

Chicago has and must continue to use Lake Michigan water for domestic purposes. It also—up to January, 1900—discharged its own raw untreated sewage into Lake Michigan thus greatly polluting its water supply and killing many of its inhabitants with water-borne diseases.

SEC. 36. CREATION OF SANITARY DISTRICT

The sanitary district of Chicago “created by the General Assembly of Illinois in 1889” embraces Chicago and 49 other towns. The district has an area of 437 square miles and was created to handle the sewage and water problem of Chicago.

SEC. 37. DEFINITION OF CHICAGO DRAINAGE CANAL

The Continental Divide between the drainage basin of the St. Lawrence and the Mississippi Rivers is close to Chicago, as shown in figure 1. The Chicago River, a very sluggish stream, normally drains into Lake Michigan. The Des Plaines River—a tributary of the Mississippi, via the Illinois River—is about 10 miles west from Lake Michigan.

The Chicago Drainage Canal is an artificial channel cut through the Continental Divide and extends 28 miles from the Chicago River

¹The material quoted is from reports of the Chief Engineer of the United States Army.

at Robey Street to the Des Plaines River at Lockport. The Canal reverses the natural flow of the Chicago River and carries its water laden sewage away from Lake Michigan. From Willow Springs to Lockport, for 15 miles, the canal was blasted out of solid rock.

SEC. 38. WHY CHICAGO STILL HAS A WATER DIVERSION PROBLEM

This is because, instead of using modern sewage treatment and disposal methods, Chicago is still following the medieval method of dumping its raw untreated sewage in the Chicago River and in order to protect its water supply is diverting water from Lake Michigan to reverse the natural flow of this River and flush raw sewage into, first, the Des Plaines River, then into the Illinois River.

The difficulties in Chicago's sewage problem are probably greater than for any other inland city for the reasons given in Sections 44 and 47. The city has spent much money in experimental work in getting fundamental data as to the best plan for treating its sewage and to-day there are no grounds for delay on account of lack of information.

SEC. 39. UNNECESSARY USE OF DOMESTIC WATER IN CHICAGO

"Chicago's present domestic water consumption diverts water from Lake Michigan at the rate of 1,200 cu. ft. per second. About 90% of the domestic consumers in Chicago get their water on a flat rate without meters." This always results in water waste, and "Chicago has a per capita water consumption of 275 gallons per day."

Cleveland, with universal meters, uses slightly less than 100 gallons per day. Chicago, therefore, uses 175% more water per capita than Cleveland. As the Chicago domestic water goes into the sewage, which is diverted from the Lakes, it represents a permanent loss to Niagara Falls.

SEC. 40. LEGAL STATUS

"The Chicago Sanitary Canal was constructed without the sanction of Congress. The present permit which is temporary and revokable, dated January 17, 1903, permits the diversion of 4,167 cu. ft. per second."

SEC. 41. WATER THAT CHICAGO IS NOW DIVERTING

"Chicago has for years greatly exceeded the limits of its permit and is now averaging 8,000 cu. ft. per second."

SEC. 42. CHICAGO'S WATER DIVERSION COMPARED WITH THE AMERICAN FALLS

The water diversion—10,000 cu. ft. per second—that Chicago is asking for is just about equivalent to the total amount of water going over the American Falls at Niagara Falls.

SEC. 43. POWER LOSS FROM DIVERTED WATER

6,800 cu. ft. per second of the diverted water is now incidentally used in the development of power in an inefficient manner at Lockport. Only a 34 ft. fall is available and this same amount of water run through the new Queenston plant at Niagara Falls, where a head of 296 feet is utilized would generate at least 10 times as much electric power. Incidentally, this Lockport inefficient water power development is also close to the Illinois coal fields.

SEC. 44. CHICAGO'S HUGE INDUSTRIAL SEWAGE

"The population of the sanitary district is now about 3,213,000, while the human equivalent of the industrial wastes is about 1,560,000."

"The strong trade wastes from the packing industry are equivalent to the domestic sewage of 1,035,000 people and the wastes of the Corn Products Company are equivalent to domestic sewage of 380,000 people."

SEC. 45. POLLUTION OF STREAMS BELOW CHICAGO

The untreated raw sewage produces an offensive condition especially in warm weather in the Des Plaines and Illinois River.

SEC. 46. WHY CHICAGO DIVERTS WATER

The water diversion is continued because as far as Chicago is concerned—without regard to rights of others—this is the cheapest way to dispose of its sewage. Sewage treatment works would cost about \$157,000,000.

SEC. 47. WHY CHICAGO MUST CONTINUE TO DIVERT SOME WATER

With complete sewage treatment, Chicago must still—on account of its geographical position at the dead end of Lake Michigan—continue to divert a relatively small amount of water. It cannot get domestic water except from Lake Michigan and it would not safely discharge the treated sewage directly into its water supply.

SEC. 48. WHAT CHICAGO SHOULD BE HELD TO

"It is not unreasonable to insist on a reduction of flow to 6,000 cu. ft. per second by 1935 and about 5,000 cu. ft. per second by 1940, as far as the protection of the health of the community is concerned. The remedies are within the power of the state to apply; they are entirely feasible and best of all will prove of the utmost benefit and economy to the community."

SEC. 49. WELLAND CANAL WATER DIVERSION

The present Welland Canal—shown on figure 3—diverts, on an average, year around, 900 cu. ft. of water per second for navigation and 3,400 cu. ft. per second used in inefficient power development.

The new Welland Ship Canal, 25 ft. deep—locks 30 ft. deep, 80 ft. wide and 800 ft. long—now under construction and to be completed by 1930, will require about 2,000 cu. ft. per second for navigation.

SEC. 50. NEW YORK STATE BARGE CANAL DIVERSION

The New York State Barge Canal is an improvement of the old Erie, Oswego, Champlain and Seneca Canal. It extends via Buffalo from Tonawanda on the Niagara River to Troy on the Hudson. The water diversion now amounts to 500 cu. ft. per second for power used at Lockport and 1,200 cu. ft. per second for navigation.

SEC. 51. PROPOSED FUTURE CANALS

As shown on the map, figure 3, there are three proposed canals on the New York side of Lake Erie to Lake Ontario. The Welland Canal—wholly under Canadian control but available to both Canadian and United States vessels on equal terms—can handle all of the traffic. Therefore, there is no necessity for any additional canals between Lakes Erie and Ontario.

PART V

PRESERVATION OF SCENIC BEAUTY OF NIAGARA FALLS

SEC. 52. REASONS FOR NIAGARA FALLS SENTIMENT

Niagara Falls has more sentimental associations than any other water fall in the world because :

1. The geographical position of the Strait of Niagara—for it is really more of a strait than a river—between Lakes Erie and Ontario, has made this a focal point for early travel routes into what is now Canada. From the discovery of the Falls by Father Hennepin, in 1678, to the end of the War of 1812, the Niagara frontier section was under French, British and American flags, and due to its many forts, battlefields and burying grounds, contains many spots that are hallowed ground.
2. Niagara is the most sublime water fall in the world. Its awe inspiring chant, rioting rapids, surging whirlpool and constantly changing color effects create an inspiring atmosphere that tends to "poetic license" rather than fact-finding, fact-recording, and fact-facing and has stimulated more poetic and prose literature than any other water fall.¹
3. The more than one and a half million visitors annually from all over the world has resulted in an unusually wide scattering of Niagara Falls observers. Many of these visitors were honeymoon couples coming when they were in tune with the beautiful and too happy to be critical or accurately observing, and, because of this, the memories of the superficial impressions remain long after the facts are forgotten. This is why so many current beliefs regarding Niagara Falls do not square with the facts.

Any plans for further water diversion or use must cope with the above sentimental situation.

SEC. 53. GRANDEUR ASPECTS

The height of the Falls and not the volume of water is the controlling feature in the grandeur impression that is made on the spectator.

The scenic grandeur aspect depends largely upon the awe in which the spectator is held and this sensation is stimulated much more by the uniform and continuous, high, clearly visible sheet of water than by a mere wild, broken, tumbling mass.

¹For interesting development of this aspect, see 1,423 page "Anthology and Bibliography of Niagara Falls," by Charles Mason Dow, which may be purchased from the State Librarian, Albany, New York.

SEC. 54. WHY AMERICAN FALLS IS MORE BEAUTIFUL THAN
CANADIAN FALLS

The greater beauty of the American Falls than of its Canadian neighbor arises from its unbroken crestline, generous supply of a thin sheet of water, uniform distribution and clear vision because of the absence of spray.

The Canadian Falls, although carrying much more water, creates a less favorable impression than the American Falls. This is because the almost universal existence of mist and spray—as shown on plate 1—spoils the view. The abnormal concentration of the water in the V-shaped notch, rather than its uniform distribution over the crestline leaves many bare spots and gives the crestline a ragged appearance.

SEC. 55. EYE SORE EFFECTS

In November, 1924, the scenic beauty of the Falls' environment was greatly marred by offensive advertising, piles of rubbish and refuse in the gorge, unnecessary smoke from manufacturing plants, pieces of machinery scattered around on the Canadian side, and lack of harmony of structures in the gorge with their natural rock environment.

It will be noted that all of these undesirable aspects are entirely separate and distinct from any question of water diversion or power use.

Niagara Falls should be regarded as the shrine of two nations and it is not the inalienable right of any individual to do that which destroys the harmony of this masterpiece of nature.

SEC. 56. FLOW NEEDED TO FLUSH ICE

"The immense quantity of ice discharged each year by the Niagara River must receive attention in fixing the limits within which diversions are permissible. Not less than 5,000 cu. ft. per second is required to sluice ice over the American Falls and 45,000 cu. ft. per second to perform the same duty for the Canadian Falls."¹

That is, a minimum of 50,000 cu. ft. of water per second are required to cope with the ice situation at the Falls.

"In the Maid-of-the-Mist Pool below, however, a flow of at least 90,000 cu. ft. per second must be maintained in order to keep the gorge clear of ice."¹

¹ Cited from reports of the Chief Engineer of the United States Army.

SEC. 57. FLOW NEEDED FOR SCENIC EFFECT

In the beautiful American Falls, with its flow of 10,000 cu. ft. per second uniformly distributed over its 1,000 ft. crestline and, therefore, averaging a discharge of 10 cu. ft. per second per foot of crestline, nature has made its own demonstration as to what could be done to maintain proper scenic effect on the Canadian Falls. The installation of the remedial work, discussed in Section 61, so as to distribute the water uniformly along the 3,000 ft. crestline, on the same basis as nature is now giving the more beautiful American Falls, the 10 cu. ft. per second per foot of crest would require a uniformly distributed flow of 30,000 cu. ft. per second or 40,000 cu. ft. per second for both American and Canadian Falls.

If the 50,000 cu. ft. per second minimum flow needed to sluice the ice—as given in Section 56—were uniformly distributed, a much better scenic effect than exists to-day could be maintained. Enough water must, however, be delivered back into the Maid-of-the-Mist Pool so as to bring the minimum river flow up to 90,000 cu. ft. per second during the ice season in order to flush the ice out of the gorge.

The minimum flow for ice flushing, 50,000 cu. ft. per second over the Falls and 90,000 cu. ft. per second through the gorge, is, therefore, the limiting factor and represents the minimum flow.

SEC. 58. ADDITIONAL POWER THAT COULD BE DEVELOPED AND STILL MAINTAIN PROPER SCENIC EFFECT

	Rate of cu. ft. per second
The natural mean flow—average of 64 years—of Niagara River taken at	205,000
Water diversions—	Rate of cu. ft. per second
New Welland Ship Canal for navigation.....	2,000
New York State Barge Canal for navigation.....	1,200
Chicago Drainage Canal for sewage dilution.....	8,000
Diversion for power purposes authorized by present treaty.	56,000
	67,200
Minimum flow over Falls for proper scenic effect and ice sluicing	50,000
	117,200
Water that could now be harnessed.....	87,800

This water could develop about 2,500,000 additional hp. This total might be curtailed for a few days each spring to give the extra water needed to sluice the ice out of the gorge.

SEC. 59. RATE OF RECESSION

In 1906 the crestline of the American Falls was resurveyed and shown to be practically the same as in 1875. The rate of recession is about 2 inches per annum.

The map, figure 2, shows the observed crestlines of the Canadian Falls as they existed in 1764, 1842, 1875, 1906, and 1917. The rate of recession is now about 5 feet per annum. As shown on plate 2 the Falls is cutting a new gorge.

SEC. 60. WHY CANADIAN FALLS IS COMMITTING SUICIDE

What was once a beautiful horseshoe shaped crestline is now becoming ragged and V-shaped, as shown on plate 2.

The Canadian Falls carrying about 94% of the water naturally tends to cut back faster than the American Falls, and since this enormous flow is largely concentrated in the V-shaped notch, this very concentration increases the rate of recession.

If no water were diverted from the river, it would in no way retard the suicidal tendency of the Canadian Falls, but on the contrary, on account of the larger volume of water that would then be concentrated in the notch, would actually increase the rate of recession. Non-use would, therefore, not be preservation.

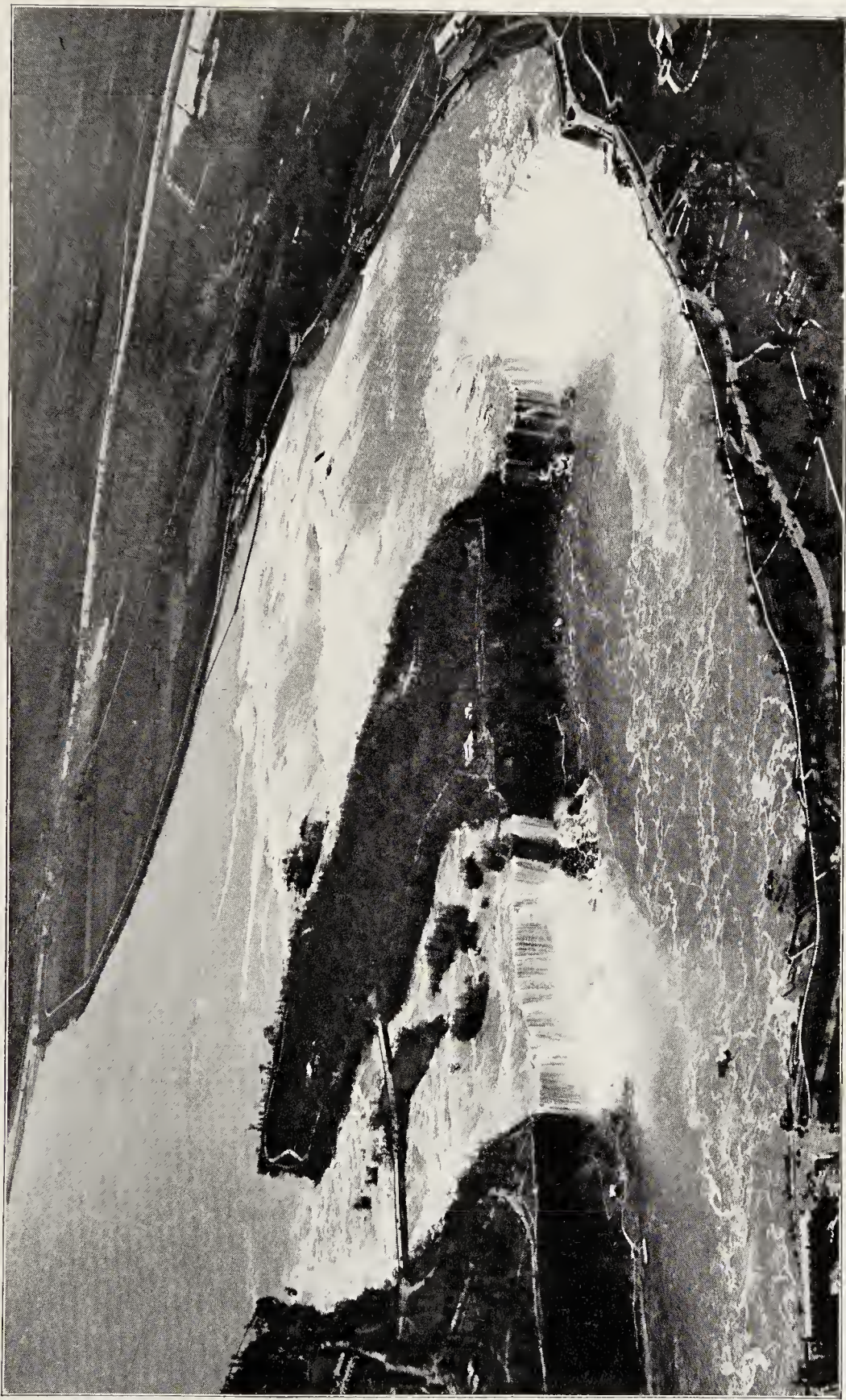
SEC. 61. ONLY WAY TO SAVE CANADIAN FALLS

By reference to figure 2 and plate 1, it will be seen that there are a number of natural islands above the American Falls. These islands help to distribute the water and tend to prevent the concentration of the water in the middle of the stream and are, therefore, an important means in preserving a uniform flow over the entire crestline of the American Falls.

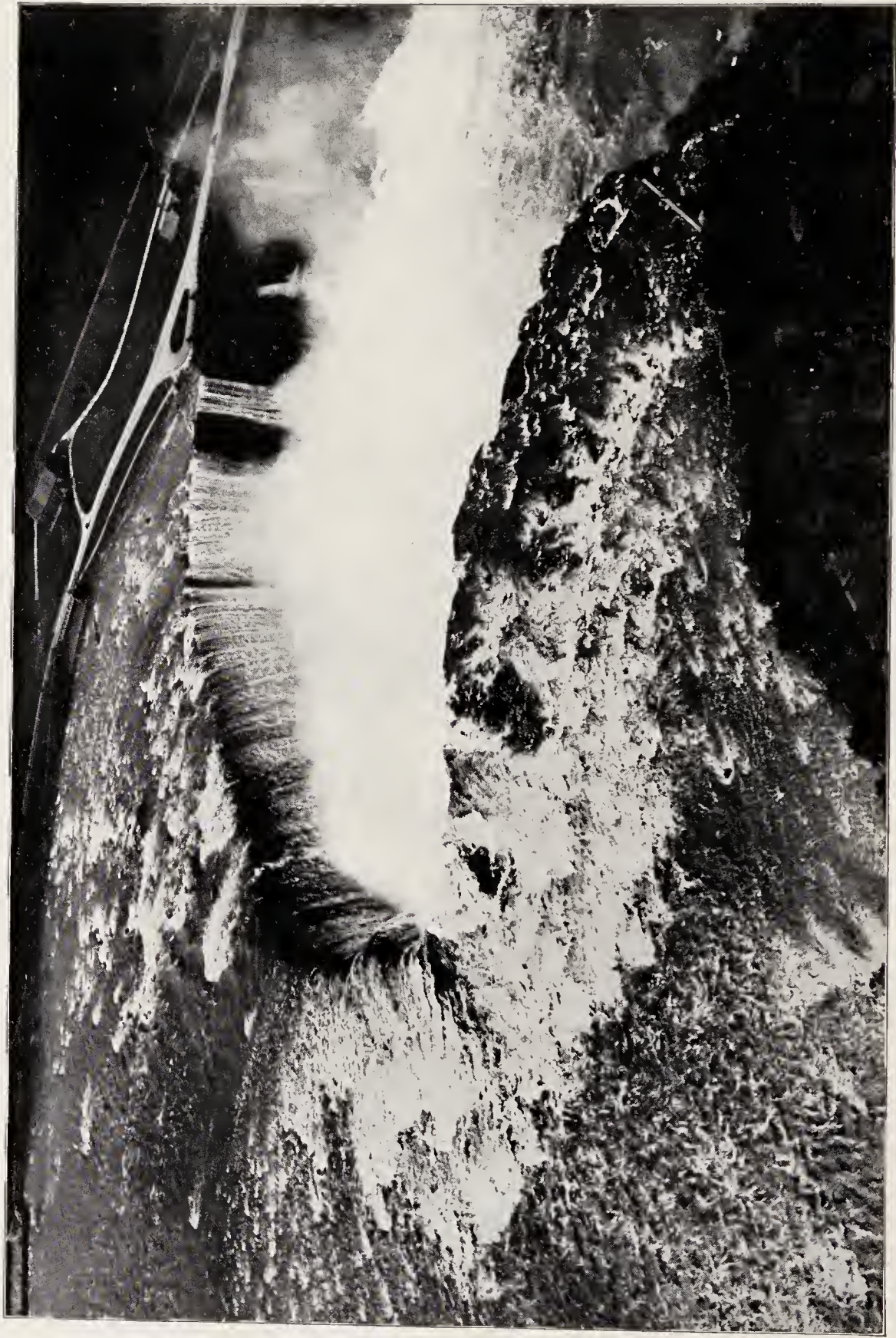
By reference to the same map, it will be seen that there are no islands in the middle of the stream flowing to the Canadian Falls. On the contrary, the group of small islands between the International boundary line and Goat Island tends actually to divert the water out into the middle of the stream.

The only way to insure the preservation of the scenic beauty of the Canadian Falls is to secure a redistribution of the flow so as to cover the entire crestline and reduce the flow to the point where mist and spray will be at a minimum.

In order to do this, it will be necessary to construct artificial islands or a submerged dyke above the Canadian Falls so as to prevent the concentration of the water in the V-shaped notch and secure a fairly uniform distribution over the entire crestline.



Aeroplane view of Niagara Falls. Canadian Falls are shown at the right, American Falls at the left, with Goat Island in between.



Canadian Falls, showing how new gorge is being formed by a rapid recession of the Falls.



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possibilities and preservation
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